Space Biosciences, SpaceX and the International Space Station

November 6, 2014

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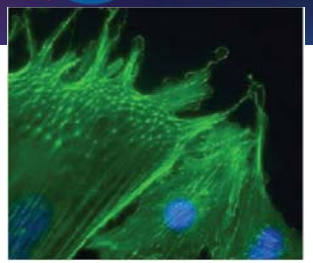
Introduction

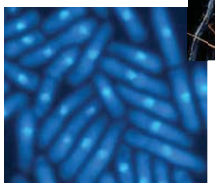
- Space Biosciences Research on the International Space Station uses living organisms to study a variety of research questions
  - To enhance our understanding of fundamental biological processes
  - To develop the foundations for a safe, productive human exploration of space
  - To improve the quality of life on earth

National Aeronautics and Space Administration

Ames

Discovery Innovations Solutions





Areas of Space Biology Research

Cell Research
- Cellular Processes
- Molecular Biology
- Differentiation
- Immunology

Animal Research
(Vertebrate and Non-Vertebrate Research)
- Physiology
- Immunology
- Development and Differentiation

Microbiology Research
- Virulence
- Biofilm
- Molecular Biology

Plants Research
- Development and Differentiation
- Cell and Molecular Biology
- Tropisms (Gravity and Light
- Biomass

Examples of Specimens Studied

- Stem Cells
- 3D Cultures
- Adherent Tissue Cultures
- Non-Adherent Tissue Cultures

- Rats
- Mice
- *D. melanogaster*
- *C. elegans*
- Newts, Geckos
- Quail
- *X. laevis*

- Bacteria
- Yeast
- Fungus
- Human Virus

- *Arabidopsis* species
- *B. rapa*
- *T. aestivum* (dwarf wheat)

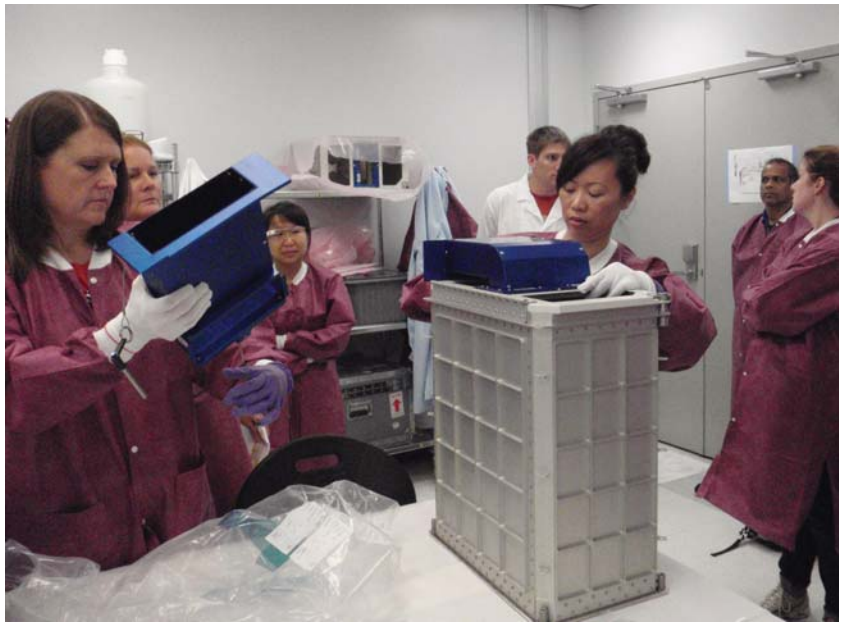
Introduction

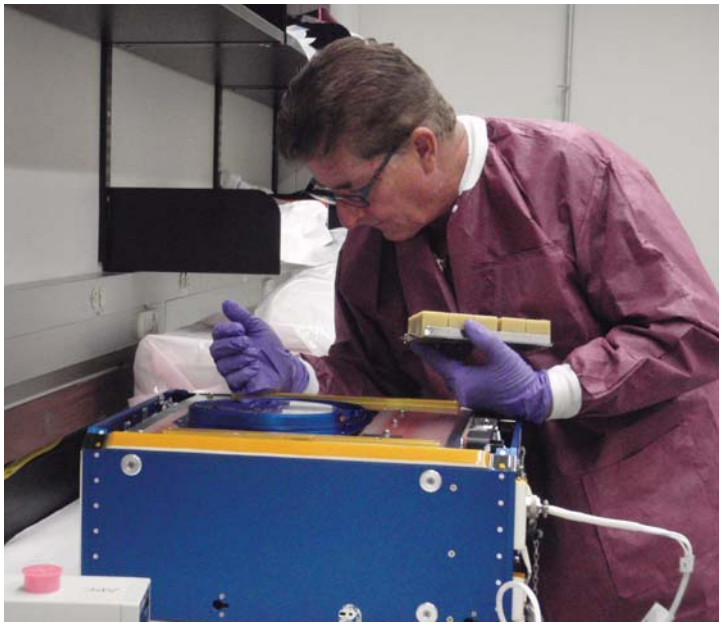
- Dragon provides the capability for
  - Late Load payloads with Scrub turnaround capability
    - Many experiments require treatments as close to microgravity exposure as possible
    - Samples are limited life
  - Powered payloads
  - Environmental controls
    - Living systems require life support
  - Specimen return
    - Allows science to
      - Perform analysis on returned samples not yet supported by on-orbit capability
      - Study living systems after micro-gravity exposure

Rodent Research

Rodent Research-1

- Launched on SpX-4 early in the morning of Sunday Sept 21, 2014 after a 24 hour scrub due to Florida weather!
- 2 day transit to the International Space Station with docking on Tuesday, Sept 23
- Animals were transferred from the Transporter to the two Rodent Research Habitats on Thursday, Sept 25
- All 20 animals were healthy and very active
- Daily video health checks performed for duration of the mission and all animals continued to appear healthy and active through out the mission






B


FLIGHT CREW SYSTEMS

Rodent Research-1

- Activities supporting Center for the Advancement of Science in Space science objectives were completed on Oct 12 – 14
  - 21 days after launch
- All samples were returned on SpX-4 which undocked on Oct 25
- Activities support NASA validation objectives were completed on Oct 29
  - 34 days after transfer to the Habitat
  - Samples will be returned on SpX-5

Rodent Research-1
Summary

Overview of Upcoming Rodent Research on ISS

- NASA's Rodent Research program traffic model is 2 flights per year on even numbered SpaceX flights
  - Flights will support up to 40 mice for up to 90 days
  - Resources will be shared between NASA sponsored investigators and investigators from CASIS

Overview of Upcoming Rodent Research on ISS

- Rodent Research-2 will be the first NASA rodent mission on the ISS with a focus on science
  - Manifested for launch on SpX-6
  - 40 mice for up to 60 days
    - 20 mice assigned to support two NASA science investigations selected through the 2012 NASA Research Announcement (NRA), Research Opportunities in Space Biology
      - Investigations on antibody responses and affects on the blood brain barrier
      - Biospecimen sharing
    - 20 mice assigned to CASIS in support of a Commercial Partner

Overview of Upcoming Rodent Research on ISS

- Rodent Research-3
  - Manifested for launch on SpX-8
  - 40 mice for up to 42 days
    - 20 mice assigned to support one NASA science investigations selected through the 2012 NASA Research Announcement (NRA), Research Opportunities in Space Biology
      - Investigations on antibody responses and affects on the blood brain barrier
      - Biospecimen Sharing
    - 20 mice assigned to CASIS in support of a Commercial partner

Overview of Upcoming Rodent Research on ISS

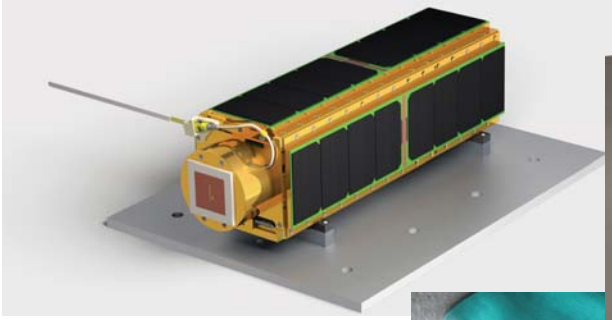
- Rodent Research-4
  - Manifested for launch on SpX-10
  - 40 mice
    - 20 mice assigned to support one NASA science investigations selected through the 2012 NASA Research Announcement (NRA), Research Opportunities in Space Biology
      - Investigations on antibody responses and affects on the blood brain barrier
      - Additional Biospecimen Sharing investigators to be selected
    - 20 mice assigned to CASIS in support of a DoD investigator
      - Requesting male mice

SpaceX -3

Space Bioscience Payloads

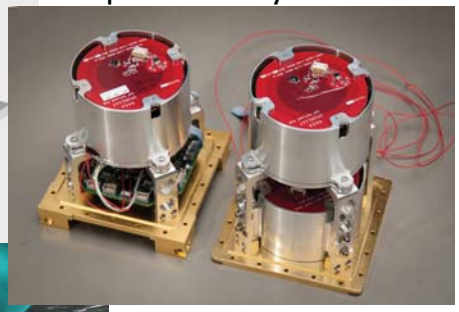
- **SporeSat (PI: Amani Salim)**
  A free-flying Nanosat that will be launched from the SpaceX rocket between the first and second stages. The experiment will study the gravity threshold of sensitivity for the single-celled fern spore revealing new information about the first moments of gravity sensing in living organisms.

- **Micro-7 (PI: Hong Lu Wu)**
  A study of gene expression in cultured human fibroblast cells to understand growth and wound healing changes in space and the combined influences of microgravity and radiation.

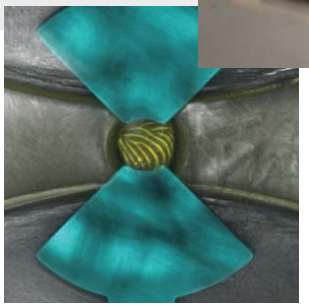


SporeSat Satellite

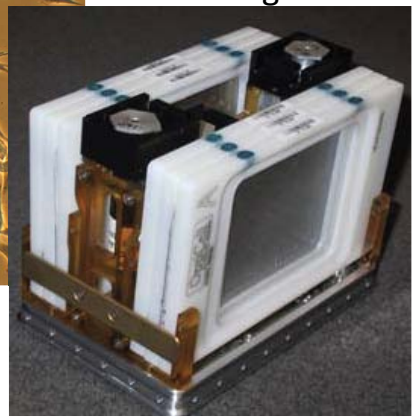
SporeSat Payload

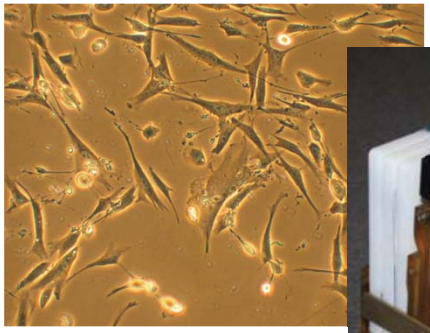


Fern Spore in the SporeSat Payload



Micro-7 BioCell Payload from BioServe Space Technologies





Human Fibroblast Cells

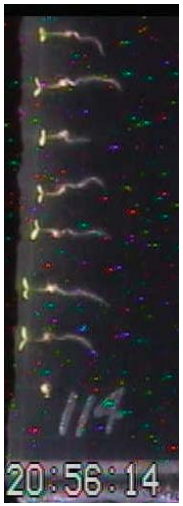
- **Seedling Growth-1 Samples Returning to Earth (PI: John Kiss, Javier Medina)**
  A study of the interactions between light and gravity sensing in plants using the on-board centrifuge, EMCS, to apply controlled doses of gravity in ways that cannot be achieved on Earth.

- **HEART FLIES (PI: Peter Lee, Stanford, Co-I: Bhattacharya, NASA ARC)** **H**eart **E**ffect **A**nalysis **R**esearch **T**eam conducting **FL**y **I**nvestigations and **E**xperiments in **S**paceflight is the first investigation to use the fruit fly, *Drosophila melanogaster,* to study the effects of spaceflight on the structure and function of the heart.

- **T-Cell Activation in Aging (PI: Millie Hughes-Fulford, NCIRE)** An investigation of the genetic and molecular mechanisms that underlie diminished T-cell activation that both occurs in the aging population and also in astronauts.

Seed Cassette Payload for Seedling Growth Experiment

Curran Reddy & Sharmila Bhattacharya inspecting tubes of fruit flies



Seedlings Grown in Space

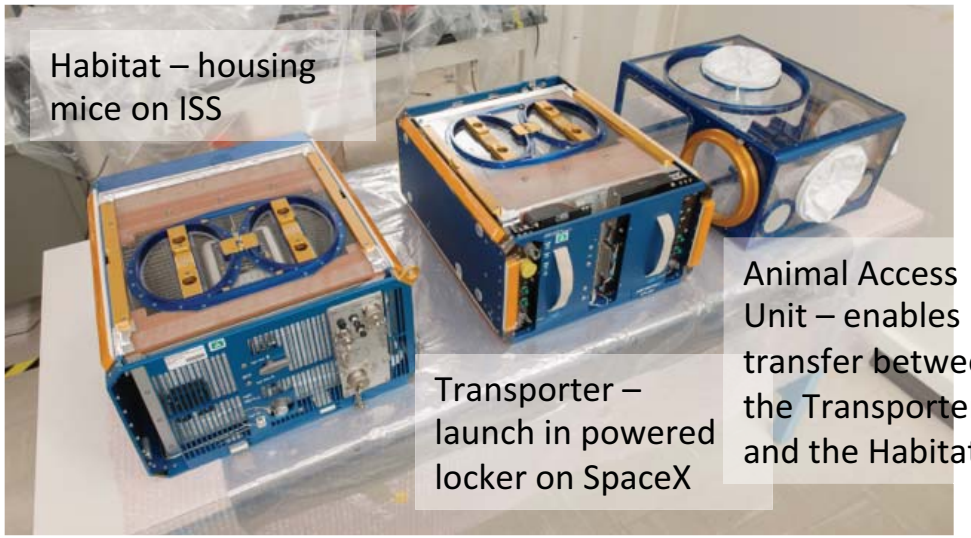
T-Cell Mission Patch

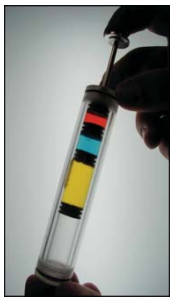
SpaceX -4

Space Bioscience Payloads

- **Rodent Research-1 (NASA Validation and CASIS)**
  The first flight of the Rodent Habitat and the Rodent Transporter. Twenty mice will live onboard ISS for 30 days. Animals will be euthanized on ISS and tissues returned to Earth for analysis. NASA analysis will focus on animal health and general adaptation to the habitat and the space environment; CASIS analysis will focus on commercial applications related to muscle disease

- **Micro-8 (PI**: Neilsen-Preiss**)**
  A study of the common fungus, *Candida albicans,* to understand physiological adaptations to the space environment that can alter pathogenicity to humans and a test of antimicrobial treatment on cultures flown in space.





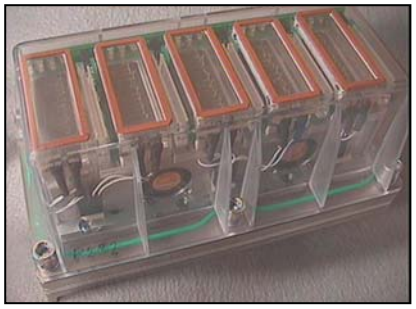
Micro-8 Fluid Processing Apparatus

BioServe Space Technolgies

Micro-8 Commercial Generic Bioprocessing Apparatus

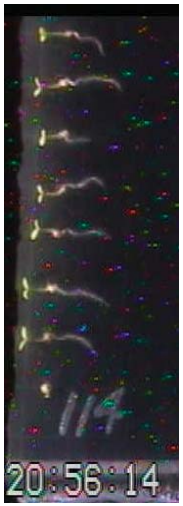
- **Seedling Growth-2 (PI: John Kiss, Javier Medina)**
  A study of the interactions between light and gravity sensing in plants using the on-board centrifuge, EMCS, to apply controlled doses of gravity in ways that cannot be achieved on Earth.

- **Ames student Fruit-fly Experiment (AFEx) (Mentor: Sharmila Bhattacharya)** The American Society for Gravitational Space Research has sponsored this student experiment to study the relationship between oxidative stress and behavioral adaptation to microgravity in the fruit fly, *Drosophila melanogaster.*



Seed Cassette Payload for Seedling Growth Experiment

Seedlings Grown in Space



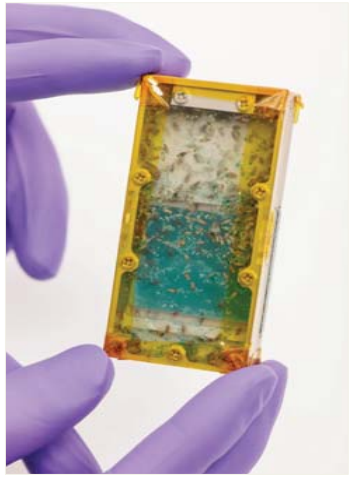
The fruit fly, *Drosophila melanogaster*

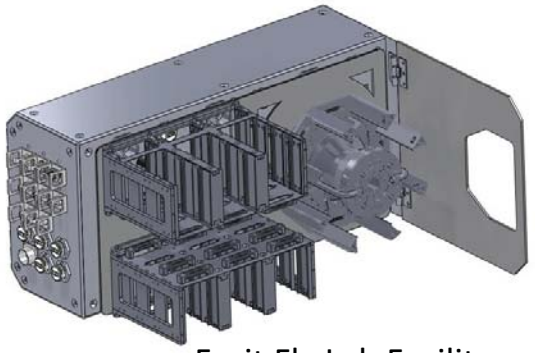
SpaceX -5

Space Bioscience Payloads

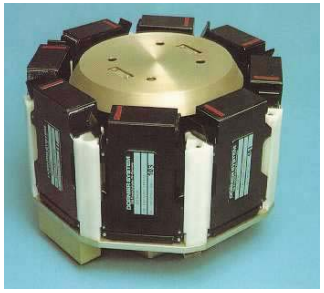
- **Fruit Fly Lab-1 (NASA Validation)**

  The first flight of the Fruit Fly Lab to support multi-generational experiments with *Drosophila melanogaster* (fruit flies) at various gravity levels (0 to 2 g). This system will allow for studies of genetic responses to micro- and fractional-gravity and effects on reproduction in a complex organism that has been extensively used in labs around the world for such studies. This is a capability that is lacking, but desired, by all of the international partners for on-orbit space biology research.





Fruit Fly Lab Facility



Fruit Fly Lab Rotor with Containers

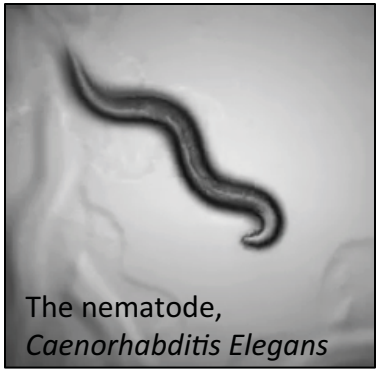
- **Micro-5 (PI: Cheryl Nickerson)**

  A study to determine the effect of space flight on the host-pathogen interaction in real time as a function of media ion composition when both *C. elegans* (host) and *S.* Typhimurium (pathogen) are simultaneously exposed to spaceflight.

BioServe Space Technolgies

Micro-5 BioCell

Micro-5 Commercial Generic Bioprocessing Apparatus



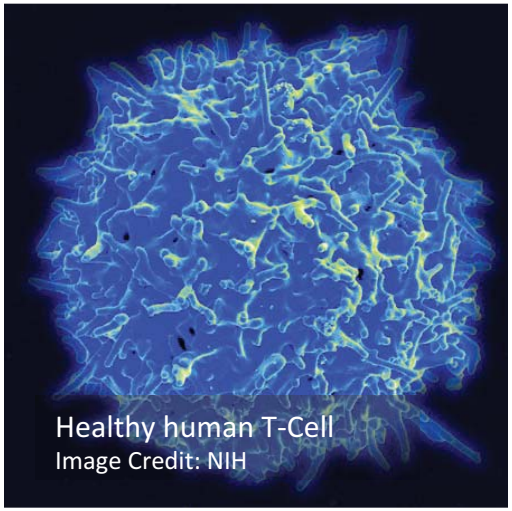
The nematode, *Caenorhabditis Elegans*

Bioculture System Validation 1st flight of NASA's Bioculture System. This validation study will involve the culture of living cells for a period of up to 30 days. Ground studies and post flight analysis will be conducted at Ames Research Center.


Bioculture System


Cell Science-1 includes cardiomyocytes grown on beads

T-Cell Activation In Aging (PI: Millie Hughes-Fulford Ph.D., Northern California Institute for Research and Education) The second flight of a two-part mission to investigate the genetic and molecular mechanisms that underlie diminished T-cell activation that both occurs in the aging population and also in astronauts.


Healthy human T-Cell
Image Credit: NIH